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Electromyographic Analysis of Hip Muscle Activity during Stair Climbing: A Pilot Study

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ELECTROMYOGRAPHIC ANALYSIS OF HIP MUSCLE ACTIVITY DURING STAIR
CLIMBING: A PILOT STUDY

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A Scholarly Project Submitted to the Graduate Faculty of the

Department of Physical Therapy
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University of North Dakota

in partial fulfillment of the requirements for the degree of


Doctor of Physical Therapy

Grand Forks, North Dakota
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This Scholarly Project, submitted by Alexander Barney, Mary Loken, Paige Torgerson, and Lyndsey Wunderlich in partial fulfillment of the requirements for the Degree of Doctor of Physical Therapy from the University of North Dakota, has been read by the Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.



(Graduate School Advisor)



(Chairperson, Physical Therapy)

PERMISSION

Title Electromyographic Analysis of Hip Muscle Activity During Stair Climbing: A Pilot Study

Department Physical Therapy

Degree Doctor of Physical Therapy

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TABLE OF CONTENTS

LIST OF FIGURES	vi
LIST OF TABLES	vii
ACKNOWLEDGEMENTS	viii
ABSTRACT	ix
CHAPTER	
I. INTRODUCTION	1
II. SUBJECTS	2
III. METHODS	3
IV. RESULTS	5
V. DISCUSSION	7
VI. CONCLUSIONS	8
APPENDIX	9
REFERENCES	10

LIST OF FIGURES

Figure 1. Comparison of the Percent of Maximal Voluntary Contraction (MVC) of Tensor Fascia Latae and Gluteus Medius Muscle Activity During Walking, Normal Ascending Stair Climbing, and Normal Ascending Sideways Stair Climbing (Right Lower Extremity Leading)	6
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LIST OF TABLES

Table 1. Subject Characteristics	2
Table 2: Subjects and their respective EMG output of Gluteus Medius and Tensor Fascia Latae during Functional Activities	9

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ABSTRACT

Introduction: Prior to this study, little evidence exists for a quality predictive tool correlating maximum velocity contraction (MVC) strength of the hip abductor muscles to walking and stair climbing (ascending/descending, side-stepping) ability. Stair climbing is an important functional activity of daily living and as physical therapists we are involved in training clients to ascend/descend stairs safely, which can be difficult for clients with hip abductor muscle weakness. **Subjects:** Eleven females voluntarily agreed to participate in this study. All participants were under the age of 30 years old, nonpregnant, physical therapy students without a current musculoskeletal injury. **Methods:** During each of the trials, the muscle activity of each muscle was recorded. The EMG activity was recorded using a Noraxon† TeleMyo2400 G2 telemetry unit with a sampling rate of 1 kHz which was transmitted to a TeloMyo PC interface card connected to a laptop computer. EMG activity was recorded by placing Blue Sensor (model M-00-S) surface electrodes on the skin over each of the muscles under study. The muscles that were monitored were the: 1) tensor fascia latae, and 2) gluteus medius. A foot switch placed inside the shoe was used to measure when the subject's right foot was on or off the ground. The four activities tested were: subject ascending stairs normally with right foot leading, subjects descending stairs normally with right foot lagging, subjects ascending stairs sideways with right foot leading, and subjects descending stairs sideways with right foot lagging. The subjects performed each activity to a set metronome to 100 bpm for level walking and 80 bpm for stair climbing. **Results:** The tensor fascia latae produced higher muscle activity than the gluteus medius during walking. During stair climbing, side-stepping produced more muscle activity as compared to normal stair ascending. The tensor fascia latae also appeared to produce a greater muscle activity than the gluteus medius during stair side-stepping. The average

gluteus medius muscle activity was equal during normal stair ascending and side-stepping ascending. **Discussion:** Side-step stair ascending has long been thought to activate and strengthen the gluteus medius muscles. These results show that this isn't the case, as the gluteus medius muscle averaged the similar EMG activity during both walking and stair-climbing. In comparison, side-stair ascending produced more activity in the tensor fascia latae than did normal stair ascending. **Conclusions:** The results indicate that using side-step stair climbing to increase strength and activity of the gluteus medius muscle doesn't appear to be justifiable. However, they do show that the tensor fascia latae and gluteus medius are both important for stair-ascending in patients without compensation. Thus, strengthening the tensor fascia latae may be just as important as the gluteus medius for stair-climbing.

CHAPTER I

INTRODUCTION

Stair climbing can be a limiting factor for individuals, particularly the elderly, who want to remain in their home. Previous research has indicated that stair climbing is more difficult for elderly individuals than ambulation on level surfaces.^{1,2} Verghese et al.³ studied self-reported falls in a group of 310 community residing adults aged 70 and over. They found that 140 subjects reported difficulty climbing up stairs, 83 had difficulty going down stairs and 59 had difficulty in both. Difficulty climbing down stairs was associated with a higher prevalence of falls. Falls often result in head trauma, fractures, or even death, and can be one of the major causes of loss of independent living and mobility in the elderly population.^{3,4} For the elderly, the ability to climb steps is altered by age related loss of strength and range of motion (ROM) as well as other factors that change with aging such as cardiovascular condition, vision, proprioception and cognition.³ Studies using the Functional Independence Measure (FIM)⁵ and Barthel Index⁶ found stair climbing to be one of the most difficult tasks for elderly patients.

The ability to climb stairs can also be altered due to disease and/or surgery. Marottoli et al.⁷ found that although 63% of the patients they studied could climb a flight of stairs prior to sustaining a hip fracture, only 8% were able to climb stairs 6 months after the fracture was repaired. Mayo et al.⁸ reported that 75 out of 93 patients who had strokes could not negotiate stairs independently.

Patients are generally taught to climb stairs by going in a forward direction up the stairs. An alternate way to climb stairs is by ascending them sideways. The purpose of this study was to investigate the muscle activity in two hip muscles (tensor fascia latae and gluteus medius) during forward ascension and sideways ascension of the stairs.

CHAPTER II

SUBJECTS

The volunteer subjects were selected from a sample of UND students enrolled in the professional physical therapy program. Subjects were recruited through a verbal invitation to participate and a sign-up sheet in the UND physical therapy department. The volunteers selected were between 20 and 30 years of age, and were current physical therapy students. They were healthy with no current musculoskeletal injuries. They were capable of independently climbing a flight of stairs. Because these subjects are physical therapy students, they were trained in proper stair climbing techniques as part of their professional curriculum. Any subjects with a current musculoskeletal injury or surgery was excluded. Our subjects were physically active with good muscle strength. Subject characteristics are shown in Table 1.

Table 1. Subject Characteristics

AGE (yrs)	23	25	24	23	25	24	23	23	23	24	23
HEIGHT (cm)	170	165	163	172	64	163	153	157	159	170	175
WEIGHT (kg)	88	58	68.49	63.05	58.3	68.04	58.51	63.96	58.06	68.04	68.95

CHAPTER III

METHODS

Equipment:

During each of the trials, the muscle activity of each muscle was recorded. The EMG activity was recorded using a Noraxon† TeleMyo2400 G2 telemetry unit with a sampling rate of 1 kHz which was transmitted to a TeloMyo PC interface card connected to a laptop computer. The digitized information was stored on a laptop computer. Data analysis was performed using the MyoResearch XP 1.07 software. EMG activity was recorded by placing Blue Sensor (model M-00-S) surface electrodes on the skin over each of the muscles under study.

The muscles that were monitored were the: 1) tensor fascia latae, and 2) gluteus medius. Before applying the electrodes, the skin was shaved and cleansed with isopropyl alcohol. The electrodes were placed in accordance with standardized lead positions.^{9,10} A foot switch placed inside the shoe was used to determine when the subject's foot was on or off the step. The EMG and footswitch outputs were connected to the TeleMyo 2400 G2 transmitter, worn on a belt pack and transmitted to the Telemyo PC interface card connected to a laptop computer.

Procedure:

Abductor Protocol

1. Prepare skin and place electrodes on right side of subject: (SENIAM)
2. Tensor Fascia Latae: With the lower extremity extended. Proximally 1/6 the distance on a line from the ASIS to the lateral femoral condyle (2 cm inferior to the ASIS parallel to the belly of the TFL).
3. Gluteus Medius: Place electrodes over muscle belly 1/2 the distance from the iliac crest to the greater trochanter. (anterior to the gluteus maximus)

4. Place Footswitch in right shoe
5. Have subject walk normally to get a walking baseline of activity
6. Set metronome to 100 bpm for level walking and 80 bpm for stair climbing
7. Have subject ascend stairs normally with right foot leading
8. Have subject descend stairs normally with right foot lagging
9. Have subject ascend stairs sideways with right foot leading
10. Have subject descend stairs sideways with right foot lagging

Data analysis was accomplished using the Noraxon MyoResearch software. The EMG data was normalized based on the muscle activity of each subject recorded during the elicitation of a maximal voluntary contraction. The EMG data from the stair climbing trials were expressed as percentages of the maximal voluntary contraction.

CHAPTER IV

RESULTS

The tensor fascia latae had slightly greater muscle activity than the gluteus medius during level walking (Figure 1). Normal stair ascending produced similar EMG activity to walking in terms of the tensor fascia latae. Side-step stair ascending produced much higher activity level in the TFL than compared to walking. The gluteus medius showed slightly more electromyography activity during stair-climbing than in walking. This held true for both normal stair ascending and side-stepping ascending. For the tensor fascia latae, side-step stair climbing produced more muscle activity than normal stair climbing.

In contrast, the gluteus medius produced nearly the same percent of activity during side step stairclimbing as during normal stair climbing. The tensor fascia latae produced a greater percent of MVC than the gluteus medius during side-stepping ascending at nearly 36% of the maximal voluntary contraction. Both of the muscles produced much less activity during stair climbing than they did during a normal voluntary, isometric contraction.

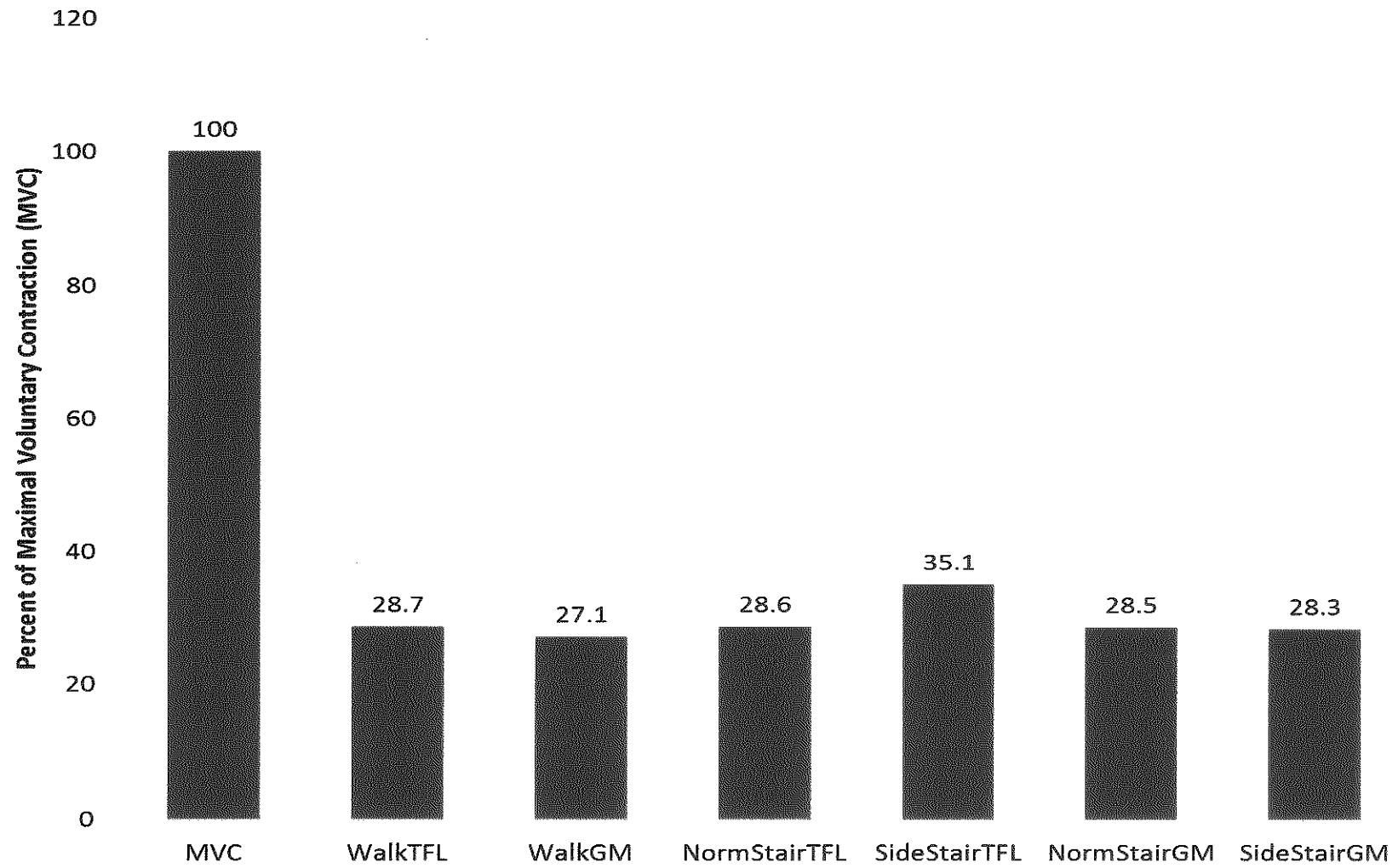


Figure 1. Comparison of the Percent of Maximal Voluntary Contraction (MVC) of Tensor Fascia Latae and Gluteus Medius Muscle Activity During Walking, Normal Ascending Stair Climbing, and Normal Ascending Sideways Stair Climbing (Right Lower Extremity Leading).

CHAPTER V

DISCUSSION

The results of the study indicate tensor fascia latae and gluteus medius muscle activity is relatively equal for walking and ascending the stairs; however, more tensor fascia latae muscle activity was required for ascending sideways stair climbing than ascending stairs in the normal manner. These results suggest that both the tensor fascia latae and gluteus medius muscles are important for stair-climbing in patients who are able to ambulate without compensation. We believe the tensor fascia latae had greater muscle activity compared to the gluteus medius because it's located more anteriorly in the thigh than the gluteus medius and therefore acts as both a hip flexor and a hip abductor. However, the gluteus medius muscle's primary function has always been considered to be a hip abduction. Therefore, we would have predicted that the gluteus medius would have been more active in side step stair climbing than forward stair climbing. The results of our study showing the same level of activity in both methods of stair climbing is surprising to us. Although some therapists use side step stair climbing to increase activity and strength in the gluteus medius muscle, this intervention does not appear to be justified over normal stair climbing.

CHAPTER VI

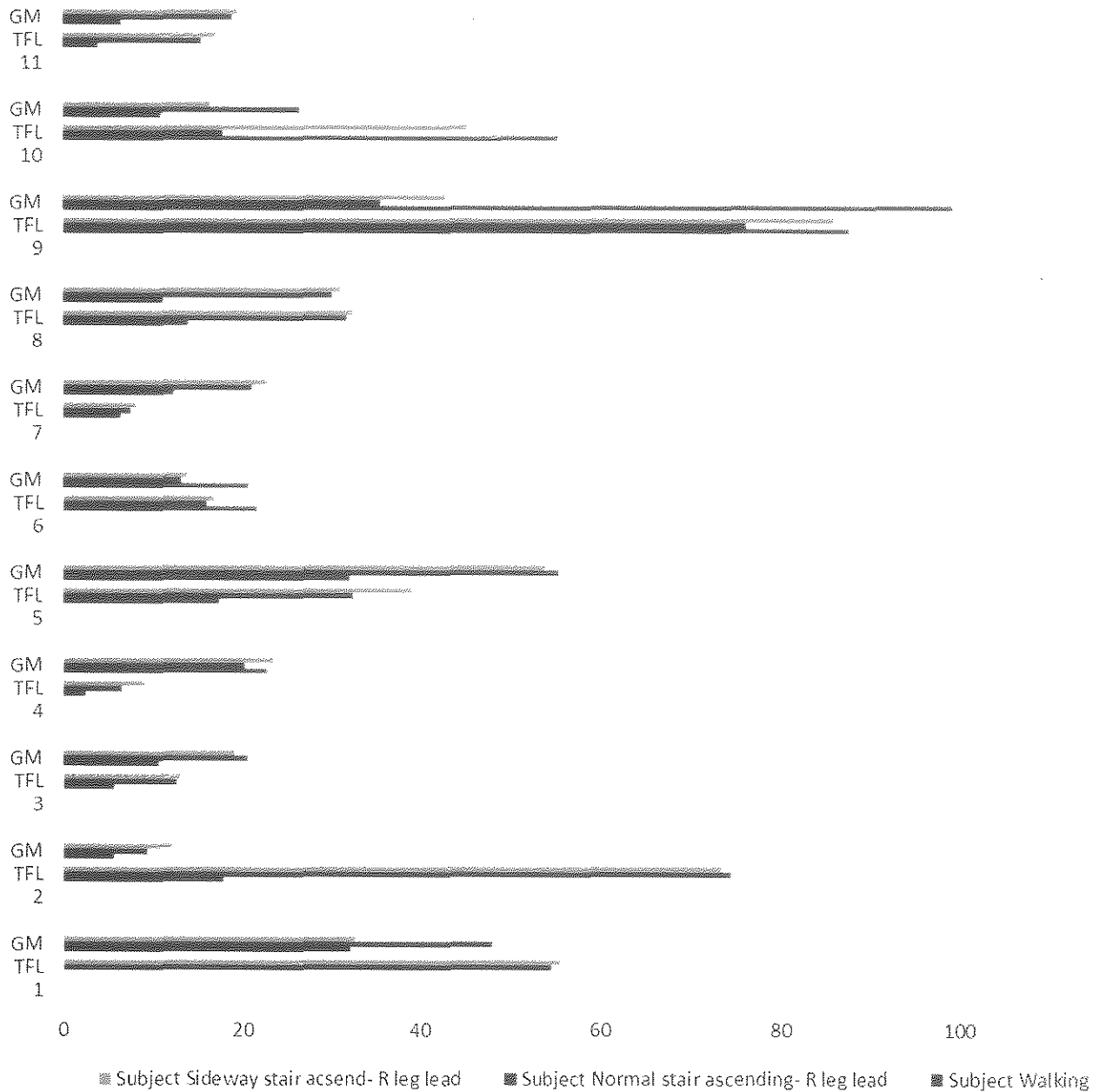
CONCLUSIONS

Our study analyzing muscle activity of the hip during functional tasks showed that the tensor fascia latae is just as essential as the gluteus medius during functional activities such as walking and stair-climbing. EMG data showed a greater level of activity in the tensor fascia latae than the gluteus medius in side-step stair-climbing, and a similar level in normal stair-climbing. Thus, strengthening of the tensor fascia latae should play just as important of a role as the gluteus medius in the rehabilitation of a patient who has difficulty climbing stairs due to hip pathology. Both muscles were active during normal and side step stair climbing. Interestingly, the gluteus medius showed the same level of activity during stair climbing as it did during normal walking. Using side step stair climbing to increase the level of gluteus medius activity does not appear to be justified.

One limiting factor of this study is that all subjects were healthy individuals without comorbidities or hip pathology. Further studies may look at muscle activity and substitution patterns in patients with hip pathology and weakness. Another potential study could measure the EMG output of hip abductor muscles in the stance limb. In addition, a study with a larger number of subjects would need to be done to increase the predictive power of the results.

APPENDIX

Table 2: Subjects and their respective EMG output of Gluteus Medius and Tensor Fascia Latae during Functional Activities



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